BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 21, Issue 12

DOI:10.58240/1829006X-2025.21.12-372

ORIGINAL RESEARCH

EVALUATION OF THE TRANSFER STRENGTH OF ORTHO-ACRYL AS A REPAIR MATERIAL FOR ACRYLIC DENTURE BASE

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Received: Nov 29. 2025; **Accepted:** Dec 27, 2025; **Published:** Dec. 31, 2025

Abstract

Background: A significant clinical concern is the acrylic resin dental plate basis fracture, which is a key prosthetic issue for both patients and dentists. Commonly, dentists repair denture base fractures using a repair material that has distinct properties.

Obective: The purpose of this paper is to investigate the transverse durability of heated-cure acrylic resin under repairing via auto-polymerizing acrylic resinous viscous substance and Ortho-acrylic resin materials.

Materials and Methods: Thirty transverse bond strength test specimens were prepared and fell into three groupings counting on the type of repair material used. The control group consisted of intact heated-cure acrylic resin samples made for testing. The Ortho-acrylic specimen group, on the other hand, was created using a doughing technique and cured using water under air pressure and continual heating with Ivomat. While Group 3, repairs were conducted using auto-polymerizing acrylic resin. The three-point bending transverse strength test was made using an Instron Universal.

Results: The controlling group (heat) uncovered a greater mean value in comparison to the other groupings; yet, the cold group demonstrated the least value of transverse bond durability. The variance among all groups is uniform, and the one-way ANOVA indicates that the significance value is more than 0.05.

Conclusion: The minimum transverse durability for the heat-polymerized acrylic resin dental plate basis materials ought to be at least 65 MPa. The current work found that the control and Ortho-acrylic groups exhibited transverse strengths above 65 MPa. In this investigation, the Ortho-acrylic repair materials were applied by first layering a powder, followed by a layer of fluid, using gentle pendulum movements. This approach has the potential to lengthen the time it takes for the monomer to spread and cover the repaired surface, which may improve the transverse durability of the substance.

Keywords: Heat-cured acrylic, Cold-cured acrylic, Ortho-acrylic, Transverse strength

INTRODUCTION

Unfortunately, fracturing the acrylic resin dental plate base is a major prosthetic issue for both patients and dentists[1]. The failure of the dental plate base material occurs during function, both outside and inside. Continuous flexing of the dental plate base in the one's oral cavity mouth leads to failure. As a result of crack propagation, this causes a midline fracture. While outside failure occurs when dropped on a hard surface [2].Fracture denture bases are frequently repaired because reconstructing a new dental plate is a costly and timewasting method[3]. The ultimate goal of dental plate repair is to prevent more fractures, so how good the dental plate repairs counts upon strong viscosity among the denture base materials as well as the repair material. Various criteria influence the selection of repair materials, including the repair's transverse strength, color, ease of use, speed, cost-effectiveness, and the level of dimensional accuracy required[4]. Researchers have proposed various materials for repairing fractured denture bases. For instance, there are acrylic resinous substance that are heat-polymerized, auto-polymerized, and light-polymerized[5]. However, in the repairing operation, auto-polymerizing resins are usually chosen

as they are cheap, easy to use, and don't take long to dry[6]. Although acrylic resin materials have advantages like color matching ability, dimensional stability, low cost, easy manipulation, and light weight, they also have disadvantages such as low fractural strength, impact strength, and resisting low tiredness[7]. Despite the limited research on the transverse strong point of heat-cured acrylic resinous substance repair using various materials, this study examined the transverse durability of heat-cured acrylic resins got repairing by using auto-polymerizing acrylic resins and Ortho-acrylic resinous viscosity substance ingredients.

2. MATERIALS AND METHODS

2.1. Acrylic specimen's preparing

Used 3D image software and a 3D milling machine to make a metal pattern in sake of the transverse bond durability test, following ADA properties No. 12, 1999. The pattern was 65 mm length, 10 mm width, and 2.5 mm thickness, (Gungor et al., 2017), shown in (Fig. 1.)

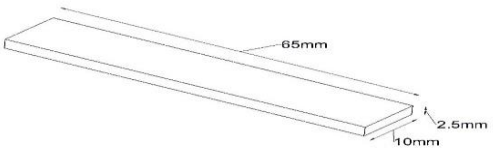

Figure 1. Diagram of 3D image software design of transverse bond strength specimens test .

A silicon mold was used to facilitate the test specimen processing. The silicon mold was prepared by using a rectangular metal tray with scopes of 76 mm in length, 70 mm in width, and 10 mm in depth, respectively (Shihab and Hussein, 2014). The steel tray was used to prepare an even, symmetrical, and homogenous block of silicon for all tested materials (Agarwal et al., 2019). The silicon was blended based on the producer's guidelines and filled the metal tray with it evenly; after that, the metal patterns were entrenched in the silicon (Fig. 2).

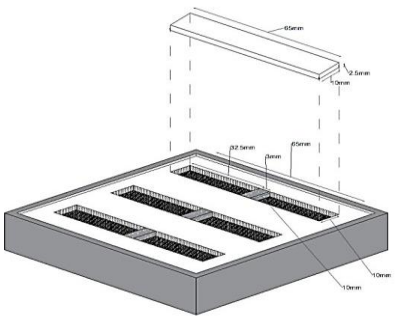

Figure 2. Diagram showing the facilitation of the test specimens processing.

Then flasked the silicon mold containing the specimens using a dental stone (Hamad, 2015b), and then carefully removed the metal patterns from the mold. To make a repair space for the specimens, use a metal spacer bar with scopes of 3.0 x 10.0 x 2.5 mm3 and place it in the core of repairing space for standardization (Arioli Filho et al., 2011). Only groups 2 and 3 received the metal spacer bar, while the intact heat-cured acrylic resin specimens (control group) did not receive it (AlQahtani and Haralur, 2020; Kostoulas et al., 2008). Following the producer's guidelines, we mixed the heat-cured acrylic resin, packaged it into the molds, and then used hydraulic pressure (OL57 F.lli Manfredi 40060, SanSecondo diPinerolo, Italy) to make the flasks compressed under 8200 kPa for half an hour. We cured the acrylic resin in a thermostatically managed acquatic bath (Kavo EWL 5501; Kavo Elektronische GmBH, Warthausen, Germany) at 70 °C for 8 hours. It is allowed for the denture flasks to cool down to normal temperature (23 ± 2 °C) (Bural et al., 2010; Mahajan et al., 2014). We removed the acrylic specimens and finished them with 200, 600, 1500 grit sillicon carbide paper (Norton, Comerciale Técnica de Abrasivos Ltda., Campines, SP, Brazil), using continuous coolant water to remove surface excess material and irregularities. We then finalized the polishing with a polishing machine (Ayaz et al., 2014). We measured all the specimens using a digital caliper and then stockpiled them in the incubator at 37 °C in distilled water for 28 days to achieve water saturation, in accordance with ADA specification No. 12, 1999 (Aditama et al., 2019).Clean the acrylic resin samples ultrasonically with distilled water, dry them with a clean tissue, and then let them air dry for 10 seconds. This is after distilled water storage (Faltermeier et al., 2007). The intact heated-cure acrylic resin samples (control group) were ready for testing. The repaired specimens fell into two groupings, every single grouping had 10 samples, and then returned to their respective repair indications in the silicon mold after taking out the space bar. The two halves of the samples got repairing by two various acrylic resins. In grouping (2), the repair was finished. Ortho-acrylic was made based on a doughing technique and cured with DW under constant heat and air pressure (Ivomat) (Sabir and Omer, 2019). The air pressure and cure time were set according to manufacturer recommendations from Orthocryl Dentaurum, Germany, with parameters at 2 bar, 45 °C for 15 min (Hassan et al., 2019). Group (3) performed the repair using auto-polymerizing acrylic resins, mixing the P/L ratios of 10 gm per 5 ml according to the manufacturer's recommendations (Nagai et al., 2001). Once the surfaces of the auto-polymerizing resin repair materials lost their glazes, we manually packed them in the repair spaces, slightly overfilling them to let polymerization shrinking and facilitate conclusion. The polymerization was performed in a pressure pot that contained water at 45◦C and 2 bar pressure for 15 min.

This procedure was carried out to optimize the physical attributes and systematize the material's amount used in the repair (Kopperud et al., 2011). After setting the samples and removing them from the mold, excess was removed during polishing and concluding, and then the thickness and diameter of the samples were under measuring sporadically by the use of digital Venire calipers. The samples are stored at 37 °C for 48hrs in distilled deionized water (Saen-Isara et al., 2013).

2.2. Transverse test evaluation

Using the Instron universal test machine (Instron UTM, Model: 5569, U.K.), we tested the three-point bending transverse strengths by using 100 kgf at a fixed speed of 5 mm/minute in specimen's center (repairing area) until the fracture occurred (Mamatha et al., 2020). The maximal load was reported down in N and used to calculate the transverse strength according to the following equation: T = 3PI/2bd2 Mpa, where T = transverse durability (N/mm2), P = maximal load (N), L = space among the support (length of the span) (mm), b = width of the specimen (mm), and d = depth or thickness of the specimen (mm) (Furnish et al., 1983).

2.3. Microscope Analysis

Naji (2020) conducted a study that involved the examination of specimens that had fractures and underwent repair. The objective was to detect the failure modes of different types of resin materials using a polarized microscope. (Fig. 3.A,B,C).

A B C

Figure 3. Failure mode images of transverse bond strength for all groups
A: Controlling group, B: Ortho group, C:Cold acrylic group.

3. RESULT

The current datawork were analyzed by one-way ANOVA and LSD tests were adopted to define the means, revealing statistically significant differences in Transverse robustness groupings. The significance level as set at 0.05. The descriptive data for the transverse robustness test are unveiled in table (1) and fig (4). The group with maximal mean value was reported in control group A, (111.00 ± 21.354), followed by ortho group (69.60 ± 11.247), while cold group had the lowest mean value (39.20 ± 12.191).

Table 1. Descriptive data for transverse strength (Mpa) for entire groups under testing

Transver strength	N	Mean (Mpa)	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Control group (Heat)	10	111.00	21.354	95.72	126.28	75	135
Ortho group	10	69.60	11.247	61.55	77.65	52	82
Cold group	10	39.20	12.191	30.48	47.92	30	68
Total	30	73.27	33.506	60.76	85.78	30	135

Nonetheless, Table 2. uncovered a one-way (ANOVA) for the transverse robustness of numerous groupings. There was a statistically significant difference among the mean durability of the three groupings as specified by a one-way ANOVA test.

Table2. One-way ANOVA test for transverse durability among and within entire groupings.

Transverse strength	Sum of Squares	df	Mean Square	F	Sig.
Among Groups	25977.867	2	12988.933	53.298	.000
Within Groups	6580.000	27	243.704		
Total	32557.867	29			

* Mean difference significant at 0.05.

LSD- transverse strength

A level of significance of 0.05 was applied to the least significant difference (LSD) test to compare the means of both groups.

The results of the test indicated that there was a significant mean difference ($p < 0.05$) among group (controlling) and group (ortho); similarly, there was significant mean difference ($p < 0.05$) between group ortho and group cold acrylic, as presented in table 3.

Table 3. LSD analysis for transverse strength of all groupings.

(I) grouping	(J) grouping	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control group (Heat)	Ortho group	41.400*	6.981	.000	27.08	55.72
	Cold group	71.800*	6.981	.000	57.48	86.12
Ortho group	Control group	-41.400*	6.981	.000	-55.72	-27.08
	Cold group	30.400*	6.981	.000	16.08	44.72
Cold group	Control group	-71.800*	6.981	.000	-86.12	-57.48
	Ortho group	-30.400*	6.981	.000	-44.72	-16.08
*. The mean difference is significant at the 0.05 level.						

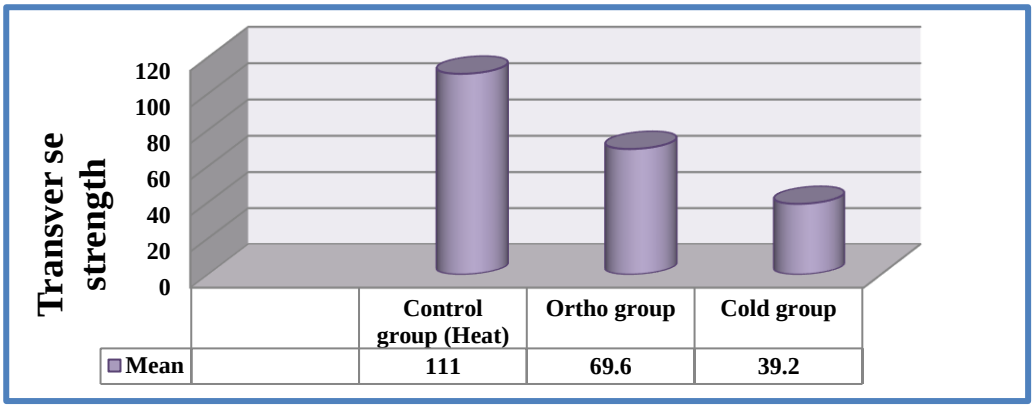

Figure 4. A bar graph illustrating the mean distribution of transverse strength (Mpa).

Figure 5, shows that cold group has extreme value that non-consistent with other values for other groups.

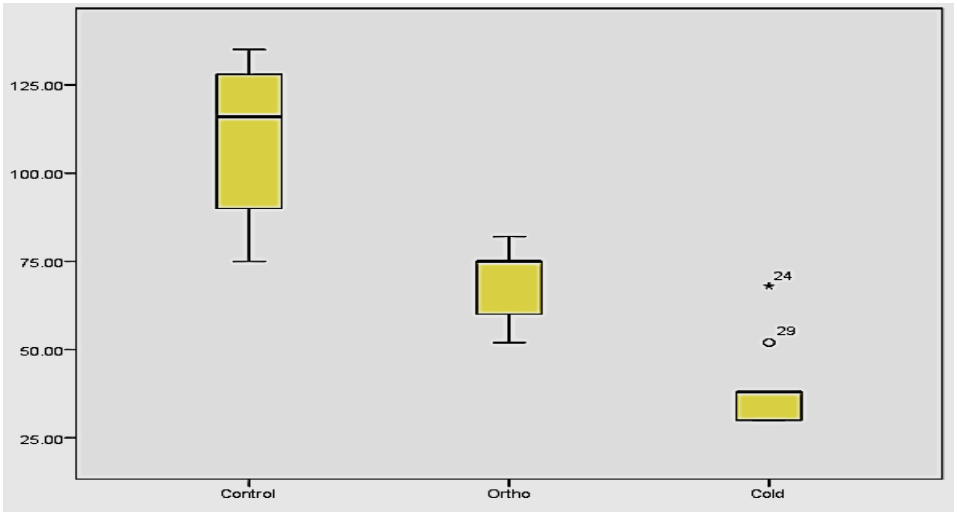

Figure 5. Plot of Boxplot of all groups.

Table 4. shows the variance between all groups is homogenous, and one-way analysis of variance with Sig. value is greater than 0.05.

Table 4. Testing Variance Homogeneity of all groups.

Testing Variances Homogeneity			
Levene Statistic	df1	df2	Sig.
3.101	2	27	.061

4 DISCUSSION

In clinical practice, denture fractures are a frequent occurrence. The denture is repaired by inserting novel substance among the fractured areas. In order to mitigate the bulk of the repairing stuff and, as a result, mitigate the polymerization shrinkage, the repairing position dimension was maintained at 3mm (AlQahtani and Haralur, 2020). The new material's bonding with old materials relies on different factors like the double bond patency for more polymerizations and designing the fracture site for repair (Syed Shujaulla, 2019) Period of time needed to make the repairs, transverse strengths achieved with the repair material as well as the degree whereby dimensional precision is obtained in repairing (Arioli Filho et al., 2011). The aiming behind our experiment was to assess the transverse power of dual different kinds of acrylic resin used for repairing rectangular samples. The findings of our investigation indicated that all the repaired groups demonstrated transverse values that were less than these seen in intact samples (controlling group). The test group revealed that the heat-cured acrylic resin (control group) got the greatest sound transverse power value, with a mean of 111 MPa. This finding is consistent with previous research (Arioli Filho et al., 2011). Then comes Ortho-acrylic resin, which has a mean value of 69.6 MPa, and the chemically auto-polymerized resin (cold group), which has a mean value of 39.2 MPa. Based on (ISO) Speci-No 20795-1, the needed transverse durability for the heat-polymerized acrylic resin dental plate base ssubstances ought to be no less than 65 MPa. The paper accepted the hypothesis by finding that the acrylic resin materials in the control and ortho groups had transverse durability higher than 65 MPa, leading to the development of a new acrylic resin material called ortho-acrylic, which can serve as a repairing substance for acrylic dental plate bases. The transverse durability of the heated-cured acrylic resin (controlling group) differed from that of the ortho-acrylic and auto-polymerized resin groups, likely due to variations in the chemical microstructure of three kinds of acrylic resin (heat, cold, and ortho-acrylic). Additionally, changes in the processing method after adding new material (repair materials) to the old material for further polymerization, as well as differences in the polymer families, contributed to the last two groups' more elastic behavior and their lower final strength values of 69.6 and 39.2 MPa. We can attribute these differences between groups to the control group's higher polymerization temperature, which could potentially boost converting rate of monomers into polymers, resulting in reduced residual monomer levels and a rise in glass temperature. (Tg) refers to the temperature at which resins transition from being brittle and glassy to becoming rubber-like. Several works uncovered that heat-cured acrylic resin exhibits lessened penetrability due to the internal creation of heat that breaks down benzoyl peroxide molecules into free radicals. However, in the current study, the auto-polymerizing repair group showed the lowest mean transverse strength value compared to the controls, which was in line with the outcomes by (Arioli Filho et al., 2011). Prior studies have indicated that denture bases repaired with auto-polymerized resin resins exhibit around 60–65% of the strength of nonrepaired PMMA acrylic resin. (AlQahtani and Haralur, 2020). Cold-cured acrylic resin polymerization is not as whole as that attained via a heated-cure system, which causes greater degrees of residual monomer. These nonreacted monomers serve as potential tissue irritants and plasticizers, resulting in higher transverse deflection values and lower transverse strength (Muhsin, 2009, AlQahtani and Haralur, 2020, Gosavi et al., 2010). Furthermore, porosity in a cold denture's base materials can occur after polymerization (Gungor et al., 2017). The residual monomer porosity and content have an impact on an acrylic resin's mechanical and physical properties (Ayaz et al., 2014). Azzarri said that the leftover monomers serve as plastic makers, lowering the interchaining durability of the polymers. This changes the acrylic resins' physical and mechanical properties and their ability to work with living things. Various factors, such as the double bond patency for multiple polymerizations, influence the bonding of the new material with the old material. The molecular weight of the unpolymerized molecule, residual monomer levels, degree of chain branching, polymer chain length, cross-linking and cross-link density within the molecule, and

existence of plastic makers and/or fillers specify the physical-mechanical attributes of polymers. The addition of plasticizers is used to make a lenient, extra resilient polymer and to reduce the polymer's glass-transition temperatures (Tg); thus, materials that are normally rigid at specific temperatures can become more flexible. In spite of ortho-crylic and cold cure acrylic resin in the same polymer families, a significant differences between the two group may be related to their difference in the method of application of the repairing materials in the fracture site, that the forte related to repaired materials transverse bond to denture basis grew significantly with chemical treatments (monomer, acetone, and chloroform), these chemicals might be scratching the surface by changingover the morphology and substance attributes of the materials. Chemicals lead to sharpness of the surface like pits, split which enhanced the bond of the under repairing stuff (Hamad, 2017). The ortho-crylic repair materials in this study were applied using the alt-and-pepper technique: apply first a layer of powder (polymer), then a layer of fluid (monomer), and continue applying alternate layers of polymer and monomer in slight pendulum movements. This technique may cause monomer infiltration into the cracks and pits, and an increased wetting duration by monomer for fixed surfaces can improve the transverse strongpoint.(Polat et al., 2013, Rached and Del-Bel Cury, 2001). They proved that using chemicals to treat the surface increased the repairing strength and could also increase the transverse strength. This was because the monomer could get into cracks and pits and make the repaired surfaces wetter for longer.

DECLARATIONS

Acknowledgments

The authors wish to affirm that they have no conflicts of interest pertaining to the current research.

Funding

This research not funding

Competing Interests

The no competing interests

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